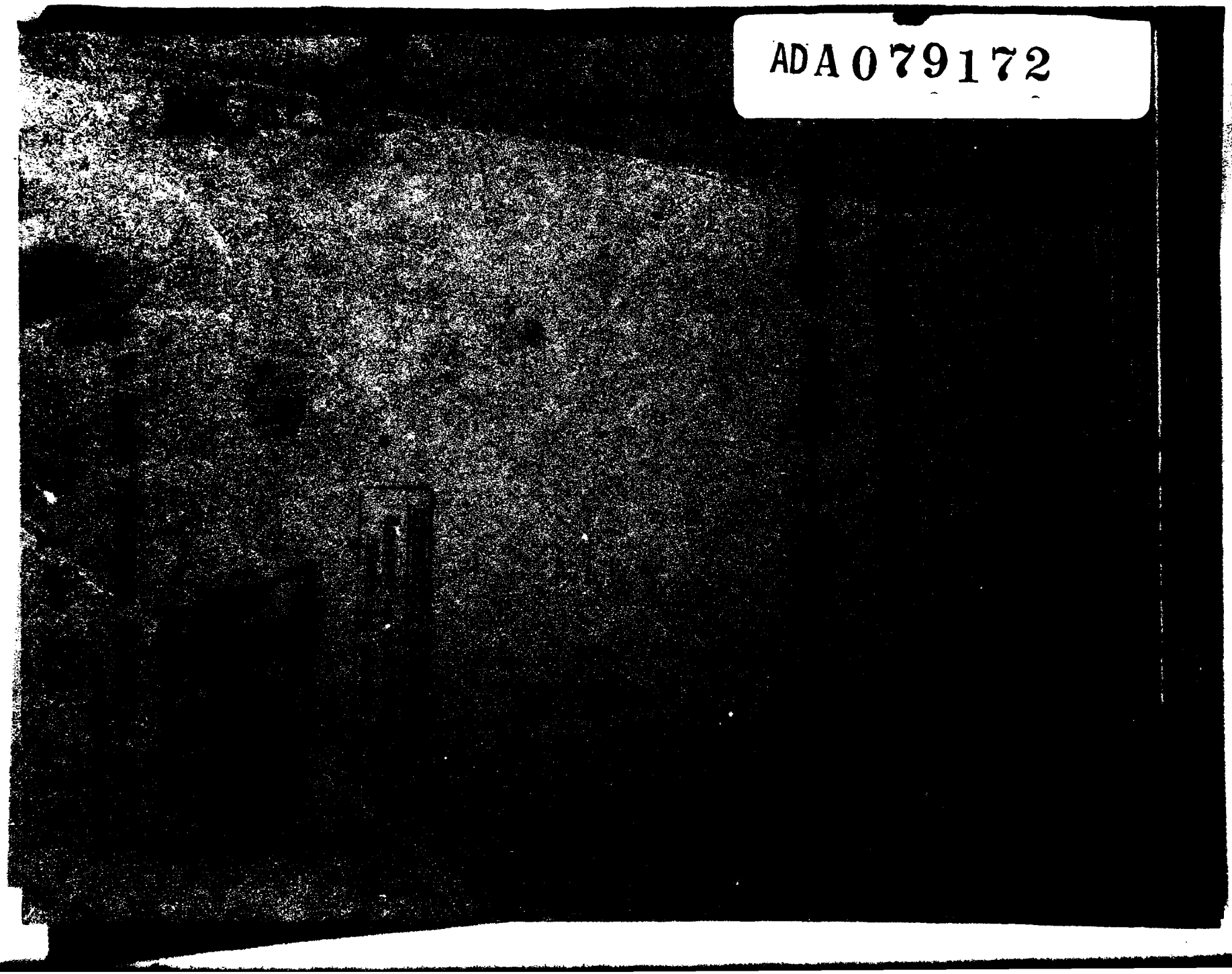
AD-A079 172 ARMY PERSONNEL RESEARCH OFFICE WASHINGTON DC F/G 5/2
MAN IN COMMAND INFORMATION PROCESSING SYSTEMS--A RESEARCH PROGR--ETC(U)
JUL 63 S RINGEL
UNCLASSIFIED APRO-RESEARCH STUDY-63-4 NL

END
DATE FILMED
2-80
DDC



(14) A+PC-Research Study-63-4

(6) MAN IN COMMAND INFORMATION PROCESSING SYSTEMS--
A RESEARCH PROGRAM,

11 Jul 63

(10) Seymour/Ringel

Submitted by

Joseph Zeidner
Chief, Support Systems Research Laboratory

Approved by

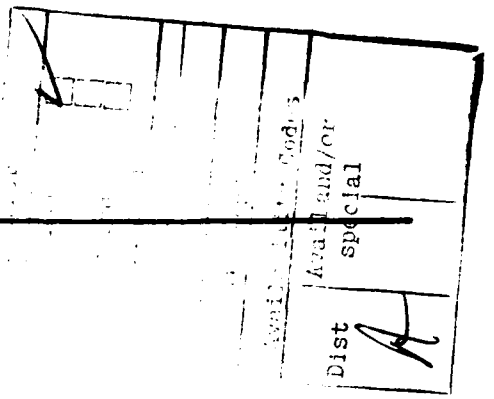
J. E. Uhlaner
Director, Research Laboratories

Hubert E. Brogden
Chief Scientist

Research Studies are special reports to military management. They are usually prepared to meet requests for research results bearing on specific management problems. A limited distribution is made--primarily to the operating agencies directly involved.

July 1963

/ AD 610 650



BRIEF

REQUIREMENT:

Technological advancements have led to increased speed, mobility, and destructive power of military operations. To permit commanders to make tactical decisions consistent with rapid change and succession of events, it is essential that information on military operations be processed and used more effectively than ever before. To meet this need, the Army is developing automated systems for receipt, processing, storage, retrieval, and display of different types and vast amounts of military data. The automated Army Tactical Operations Center (ARTOC) is a prototype of these systems. There is a concomitant requirement for research to determine how human abilities can be utilized to enable the command information processing systems to function with maximum effectiveness.

PROCEDURE:

The first step was a survey of military information processing equipment and systems and future plans in this area. Basic human factors problems were identified and organized around five critical information processing systems operations--screening incoming data, transforming raw data for input into storage devices, input, assimilation of displayed information, and decision making. Studies are in progress which will yield empirical information on specific aspects of human performance in the systems with regard to (1) characteristics of the information processed, (2) the constantly changing nature of the information, and (3) display modes--sensory modalities, group and individual displays, and (4) performance as affected by certitude and credibility of the information.

Laboratory simulation is used in the experimentation, and plans for computer simulation are under way. Procedures will, where feasible, be tried out in actual systems prior to recommendation for operational use. Finally, some effort will be expended in keeping abreast of innovations, new developments, and future command information processing systems. The purpose is to avoid the obvious shortcoming of being bound to a particular generation of systems, to maintain responsiveness to new needs through a flexible research program oriented toward providing findings with broad application.

ACCOMPLISHMENTS TO DATE:

A broad program of research has been formulated and several preliminary studies are in progress. A study on information assimilation from symbolic displays has provided information on the effects of different degrees in updating military overlays. Two other studies are in final analysis--one on relationships among certitude, display characteristics, and accuracy of information, the other on information assimilation from alpha-numeric displays.

OPERATIONAL IMPLICATIONS:

The research will assist users, designers, and developers of current and future command information processing systems in their efforts toward enhanced systems performance by providing empirical information about

1. the capabilities, limitations, and reliability of human performance

2. allocation of functions among men and equipment

3. various modes and sensory modalities of presenting information for assimilation and decision making

4. effects of characteristics of the information displayed--density, type, etc.

5. specification of effective individual and group work methods and techniques

6. procedures for identification and assignment of appropriate personnel to critical positions.

MAN IN COMMAND INFORMATION PROCESSING SYSTEMS-- A RESEARCH PROGRAM

Technological developments have led to increased adoption of newly developed complex systems by the Army. Witness the command control information system, conceived as a network of cross-linked highly automated, computerized systems, each dealing with specialized functions, and all feeding information to an automated tactical operations center. The Army Tactical Operations Center (ARTOC) is a prototype of such a system.

The U. S. Army Personnel Research Office has developed a research program designed to provide human factors information which can be useful in enhancing the output of these developing and future systems. The present research study describes the scope, rationale, and organization of the planned research program.

OBJECTIVES

The objectives of the research program are to enhance the performance of command information processing systems by providing users, developers, and designers of current and future systems with information concerning:

1. the capabilities, limitations, and reliability of human performance

2. allocation of functions among men and equipment

3. various modes and sensory modalities of presenting information for assimilation and decision making

4. effects of characteristics of the information displayed--density, type, etc.

5. specification of effective individual and group work methods and techniques

6. procedures for identification and assignment of appropriate personnel to critical positions.

THE ARTOC

MAJOR ACTIVITIES

The ARTOC is an automated facility within which are grouped representatives of general and special staff sections concerned with current tactical and tactical support operations. These representatives assist

the commander in the tactical operations aspects of his exercise of command by providing current information on the tactical support available and intelligence estimates of enemy actions, by making recommendations for command decisions, and by issuing implementing instructions. Rapid coordination among operational staff elements is essential, particularly in view of the advent of nuclear weapons and increased capabilities in electronic warfare, air defense, and mobility.

The automated TOC is designed to assist the staff in the receipt, processing, storage, display, and transmittal of information usually represented in maps, charts, journals, and work sheets. The TOC also performs certain computations on call--target analysis, fallout prediction, and troop movements--using input, storage, computing, display, and communication devices. Automation enables the center to provide information of greater scope, depth, and currency and to allow more time for consideration and use of this information in decision making. Major activities that will take place in a typical ARTOC are:

1. Continuous and simultaneous evaluation of available information by TOC elements and issuance of timely instructions.

2. Communication of tactical information and requirements to appropriate general staff sections (particularly G1, G4, and G5), and transmission of instructions to tactical units and tactical support units or agencies.

3. Continuous transmission of situation information by each element in the TOC to the corresponding element in an alternate TOC.

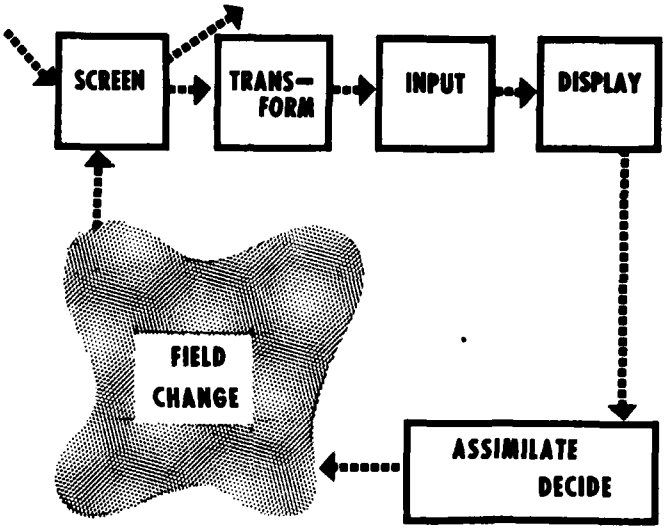
4. Continuous display and evaluation of intelligence required for current tactical and tactical support operations.

5. Continuous display of data, including essential administrative support data, on the status and operations of command and friendly forces to permit immediate decisions on tactical and tactical support operations.

CRITICAL MAN-MACHINE FUNCTIONS

The ARTOC will receive vast amounts of information from many and varied sources. The information varies widely in content, form, and degree of completeness. Further, the information often affects several different staff groups. The raw data require a great deal of handling and processing by man or by man and equipment. Personnel will work under a wide variety of conditions ranging from relatively pressure-free to overwhelmingly burdensome situations. Looking at the system as a whole, there appear to be five critical operations that man and equipment have to perform (Figure 1):

1. Screen incoming data for pertinence, credibility, impact, priority, and routing.



Schematic representation of operations and information flow in automated TOC

Figure 1. Schematic representation of operations and information flow in automated TOC

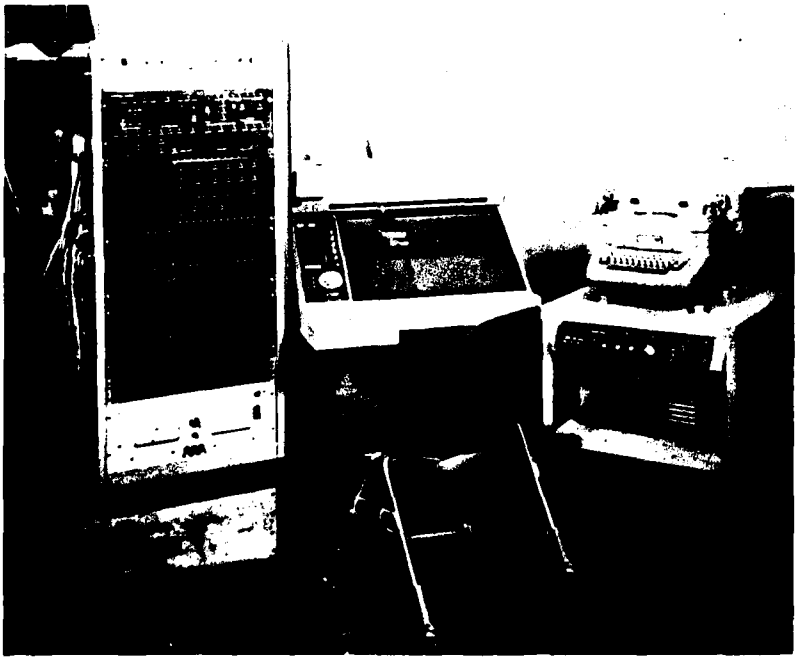


Figure 2. Example of symbolic data entry device.

2. Transform the raw data to proper format for input into storage devices.

3. Input the transformed data into storage devices for subsequent computations and displays (Figures 2, 3).

4. Assimilate data displayed (Figure 4).

5. Decide on courses of action based on information displayed and information from other sources.

Other operations that must be performed--computer programming, communication of decisions for implementation, trouble shooting and maintenance of equipment--have been deliberately excluded from the USAPRO research program as not falling within the relatively homogeneous domain of real-time processing of operational tactical information, the major focus of this program.

ROLE OF ARTOC IN THE RESEARCH PROGRAM

In planning the USAPRO research program, the ARTOC is treated as a point of departure, a prototype of command information processing systems. In these systems, there is heavy dependence on various computers, input, and output devices--the latter capable of yielding transient projected images, punched tapes, hard copy documents, and the like. With respect to the different kinds of information that must be processed and the number of different operations that must be performed by man and equipment, the ARTOC is one of the most complex systems envisaged by the Army. In this respect, the ARTOC is in contrast to air defense and fire support systems, which are more specialized in function, more delimited in kinds of information to be processed. Even in such advanced systems as ARTOC, some of the critical human operations discussed (screen, transform, input) may atrophy or disappear in the wake of further technological developments and later generation systems which will permit direct input into computers through data links. Human factors research effort and knowledge gained about such operations will not be wasted, however, since the most exotic systems are not likely to be available at all levels. Most likely, more "primitive" systems will be used at some levels as a backup for those at the higher levels. Consequently, the ARTOC is viewed as an excellent vehicle for generating useful research findings and approaches that will generalize across many automated information processing systems.

DELINEATING THE RESEARCH PROBLEMS

The major problems in command information processing systems emerge from a lack of experience in the use of such systems. From an examination of Army, Navy, and Air Force reports and human factors research literature,

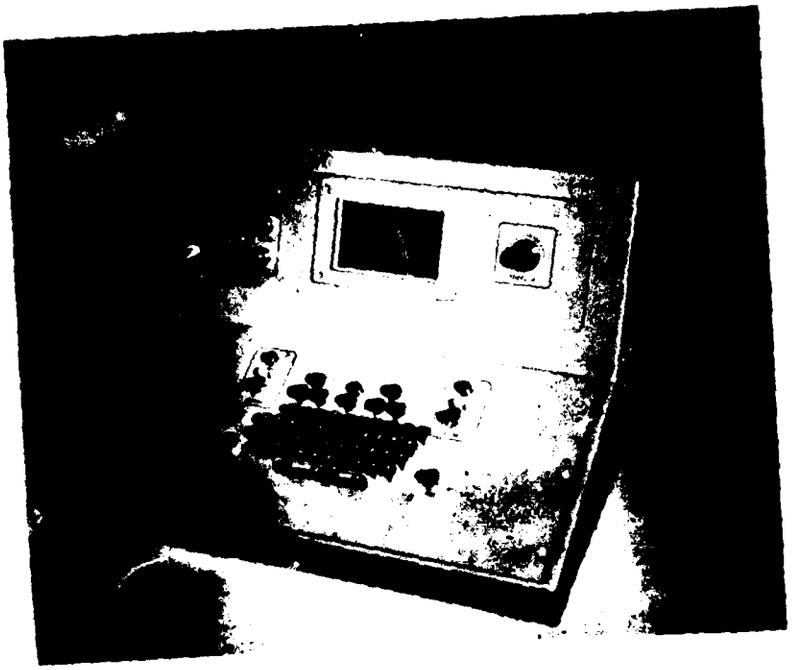


Figure 3. Example of alpha-numeric data entry device.

Figure 4. Example of group display

and from observation of equipment and subsystems in operation, a number of basic and critical questions were identified which need to be answered before such systems can be used most effectively.

As an aid in formulating specific research problems, questions requiring attention were organized in terms of their implications for the five critical human information processing functions. These questions interact within each functional area and have an impact on other areas as well. The particular grouping of questions is somewhat arbitrary, and other patternings may emerge after additional research in these information processing systems.

Since the entire automated information processing system is oriented toward providing information to the commander and his staff to assist them in the critical functions of information assimilation and decision making, current task activity centers about problem formulation and exploratory research in these two functions. The problems--and research studies designed to resolve certain of these problems--are described in some detail. The questions are stated from the point of view of optimizing accuracy, appropriateness, and speed of performance of the two functions. Questions clustering about the screening, input, and transformation of information are the subject of a more general discussion in which the nature of the research approach is indicated.

CHARACTERISTICS OF INFORMATION DISPLAYED

In the areas of decision making and information assimilation from displays of various kinds, a number of questions revolve around (1) the amount of information it is possible to absorb, integrate, and weight effectively; (2) the display densities, format, and colors that may be best for presentation of the information; (3) the most appropriate combinations of specific information and general information to be included in alpha-numeric and symbolic displays (maps and overlays), and (4) the relative effectiveness of alpha-numeric and symbolic displays for different classes of information.

The input function is directly affected by the resolution of problems in the information assimilation and decision making areas. For example, conclusions concerning amount, density, and combinations of specificity-generality of information to be presented to the commander and his staff will affect the load and demands on the input operators. Findings on the general effectiveness of alpha-numeric and symbolic displays may conflict with the efficiency with which information can be input through the corresponding input devices. While symbolic representation may be more useful in the decision making process, input of symbolic information may prove to be very costly in terms of time and accuracy, especially when different scales have to be used.

Additional considerations must be faced when the implications of these questions are traced back to the transforming operation that precedes information input. Findings can be expected to influence the amount of transforming that will have to be done, the proportions of transforming of different kinds (plain language to plain language, plain language to symbols), and the method of transforming (simple annotations such as underlining and circling versus highly formalized formats and templates).

In the information screening function, factors such as load, number and types of sorting classes, routing, and the configuration of individuals for the effective handling of large masses of varied raw data emerge from, and must be amalgamated with, all of the questions discussed above.

DYNAMIC ASPECTS OF INFORMATION DISPLAYED

A second category of questions is concerned with the dynamic or changing aspects of the information presented or displayed. What combinations of rate of information updating and degree of change in an update are optimum for assuring the conspicuity of change that has occurred? What is the utility of hard copy to the commander and his staff for pointing up trends and providing a sense of "history", for enhancing feedback of information through comparison of current information with hard copy of past information, and for manual backup and alternate TOC purposes? Where information is available at a number of levels of specificity-generality and in the form of a number of different scales, are certain sequences of viewing this information better than others?

DISPLAY MODES

A third cluster of questions addresses itself primarily to other formal or structural aspects of information display and presentation. What display or sensory modalities are best for information assimilation and decision making purposes? Are there some combinations of sensory modalities that would enhance performance? What are the relative merits of group versus individual displays? Are both kinds necessary and if so, how many of each?

CERTITUDE, PROBABILITY, AND CREDIBILITY

A fourth category of problems concerns credibility of information presented and certitude on the part of the decision maker. Is certitude a necessary condition for good performance over time? What is the relationship between certitude and performance? If certitude is an important factor in performance, can certitude be enhanced through manipulation of display characteristics? To what extent is it necessary or desirable to present to the commander and his staff qualitative statements as to credibility of the information and quantitative estimates of its probability?

RESEARCH APPROACHES

The series of studies that make up the research program--in progress or projected--have been planned to yield basic human factors information on the five critical functions in information processing. Most of the research effort for the next few years is expected to concentrate on the functions of information assimilation and decision making from displays--unless, of course, circumstances and resources indicate a shift in emphasis or broader effort.

STUDIES ON DECISION MAKING AND INFORMATION ASSIMILATION FUNCTIONS

In most of the planned series, parallel studies will be conducted with alpha-numeric and symbolic displays. The criterion or performance measures will consist of one or more measures of accuracy, appropriateness, time, and certitude. The studies will incorporate substantive, quantitative, qualitative, formal, and conceptual aspects of information and will sample problem solving situations of different complexity levels, and situations ranging from relatively slow to relatively rapid changes of events.

Amount and Density of Information. The first series of studies will have as their main variables the total amount of information presented on a single slide to a commander and his staff, and the density of this information. Different amounts and densities of information will be presented to individuals and various aspects of their responses (performance measures) to questions about the information will be recorded and analyzed. An example follows:

Military information in the form of a Friendly Tactical Units Status Tote (Figure 5) is projected on a screen to the examinees. The information is arranged in 10 columns, 10, 18, and 25 rows, and three different densities or spacings. Questions of three different levels of complexity are asked; alternative answers are distributed over five different positions. Accuracy of answers and time taken to answer will be analyzed as a function of the experimental variables.

Format and Color Coding. This series of studies will deal primarily with variations in display format and the use of color for coding and transmitting information. Various display formats, colors, and color combinations will be manipulated in order to ascertain the effects on apprehension and use of given information. Some studies will deal with horizontal-vertical, circular, matrix, and polar-coordinate types of format. In addition, simple annotation of information presented in narrative form will be tested against more elaborate and less flexible format.

FRIENDLY TACTICAL UNITS STATUS									
UNIT	LOCATION	DATE COMTD	EFFECT STRNTH	EQUIPT STATUS			CMB EFF	PRESENT ACTIVITY	REMARKS
				ARM	ART	TRN			
25 INF DIV	TN 11	OCT 62	14000	80	90	95	75	ASSEMBLING	SWAMPY TERRAIN
21 INF DIV	PT 30	NOV 62	15000	90	90	85	95	ATTACKING	FIRST ACTION
28 INF DIV	PT 30	SEPT 62	14000	75	85	80	75	ADVANCING	SWAMPY TERRAIN
22 INF DIV	XL 21	OCT 62	13000	90	95	90	85	ASSEMBLING	FIRST ACTION
34 INF DIV	PT 30	AUG 62	12000	75	95	85	80	SCREENING	FIRST ACTION
18 INF DIV	KR 14	OCT 62	15000	95	90	80	95	DEFENDING	MODERATE RESISTANCE
17 INF DIV	PT 30	NOV 62	11000	90	75	90	85	ADVANCING	MODERATE RESISTANCE
25 INF DIV	KR 14	OCT 62	15000	85	75	75	80	DEFENDING	SWAMPY TERRAIN
44 INF DIV	KR 14	NOV 62	11000	90	85	90	75	SCREENING	HIGH MORALE
23 INF DIV	LD 19	SEPT 62	12000	90	80	75	90	ASSEMBLING	COMBAT EXPERIENCED
26 INF DIV	LD 19	JULY 62	13000	95	95	95	75	DEFENDING	HIGH MORALE
33 INF DIV	XL 21	JULY 62	11000	85	90	95	90	ADVANCING	COMBAT EXPERIENCED
24 INF DIV	LD 19	AUG 62	15000	85	95	85	80	ATTACKING	HIGH MORALE
42 INF DIV	XL 21	JULY 62	12000	75	75	75	75	ADVANCING	HIGH MORALE
35 INF DIV	XL 21	OCT 62	11000	80	85	90	85	SCREENING	COMBAT EXPERIENCED
36 INF DIV	TN 11	AUG 62	13000	75	80	75	90	DEFENDING	FIRST ACTION
30 INF DIV	KR 14	JULY 62	14000	75	80	80	80	ASSEMBLING	SWAMPY TERRAIN
41 INF DIV	LD 19	NOV 62	12000	80	80	85	95	ADVANCING	MODERATE RESISTANCE
20 INF DIV	TN 11	SEPT 62	12000	85	90	80	85	ATTACKING	SWAMPY TERRAIN
29 INF DIV	PT 30	NOV 62	14000	80	75	95	85	DEFENDING	HIGH MORALE
32 INF DIV	TN 11	SEPT 62	11000	85	85	85	95	SCREENING	MODERATE RESISTANCE
31 INF DIV	LD 19	AUG 62	13000	95	95	80	80	ATTACKING	COMBAT EXPERIENCED
16 INF DIV	KR 14	SEPT 62	15000	95	80	95	90	ATTACKING	FIRST ACTION
43 INF DIV	TN 11	AUG 62	15000	95	75	75	95	ASSEMBLING	MODERATE RESISTANCE
27 INF DIV	XL 21	JULY 62	13000	80	85	90	90	SCREENING	COMBAT EXPERIENCED

Figure 5. Friendly Tactical Units Status Tote

Specificity-Generality of Information. A particularly important problem in need of resolution is the degree and combination of verbal information detail and particularization and map and overlay scales which are most effective in information processing and display systems. One study is planned in which three map and overlay scales and three levels of detail (battalion, regiment, and division, for example) will be used to present a military situation. Questions of different complexity and scope will be asked of the examinees. Accuracy of answers, "appropriateness" of decisions, time taken to respond, certitude, and frequency and sequence of viewing the different scales and levels of detail will be analyzed in terms of the complexity of questions asked.

Alpha-numeric and Symbolic Presentation. Considering the mass of information involved in large scale military operations, considerable benefit could derive from knowledge about the relative merit of presenting different classes of information alpha-numerically and symbolically. Studies in this series will seek to determine the relative effectiveness with which experimentally controlled information depicted in the two different ways is handled. Trade-off and compromise may be necessary, however, if findings in the area of decision making and information assimilation are at great odds with those in the input and other human information processing areas.

Type and Extent of Information Change. In changing situations, in addition to quantitative and formal aspects of the total context of information, the extent and type of "tolerable" information change are important factors. In an updated slide, for example, elements of information may have been removed, added, or re-positioned. What procedures will enhance the commander's awareness of significant changes, however small?

In one study, 16 pairs of slides were projected on a group display to each of eight groups of four examinees. Each pair consisted of a reference slide which contained 12, 16, 20, or 24 military symbols (Figure 6) and a test slide from which 2, 4, 6, or 8 of the original symbols had been removed. The examinees were asked to indicate which symbols had been removed and their certitude regarding the correctness of their answer. Data from this study are being analyzed to ascertain the relationships among total amount of information presented, number of elements removed, accuracy of performance, and certitude of performance. The findings will furnish information on the process of map and overlay viewing.

Rate of Information Change. A closely related area which, however, merits attention in its own right concerns the pitting of rate of information updating or change against the type and extent of change mentioned above. Obviously, some balance or flexible arrangement will have to be struck among these factors. Studies are planned to simulate slow and fast moving conditions, various rates of updating, and different amounts and types of information change to ascertain the interaction of these factors and their effects on performance. Findings will have procedural implications for systems use.

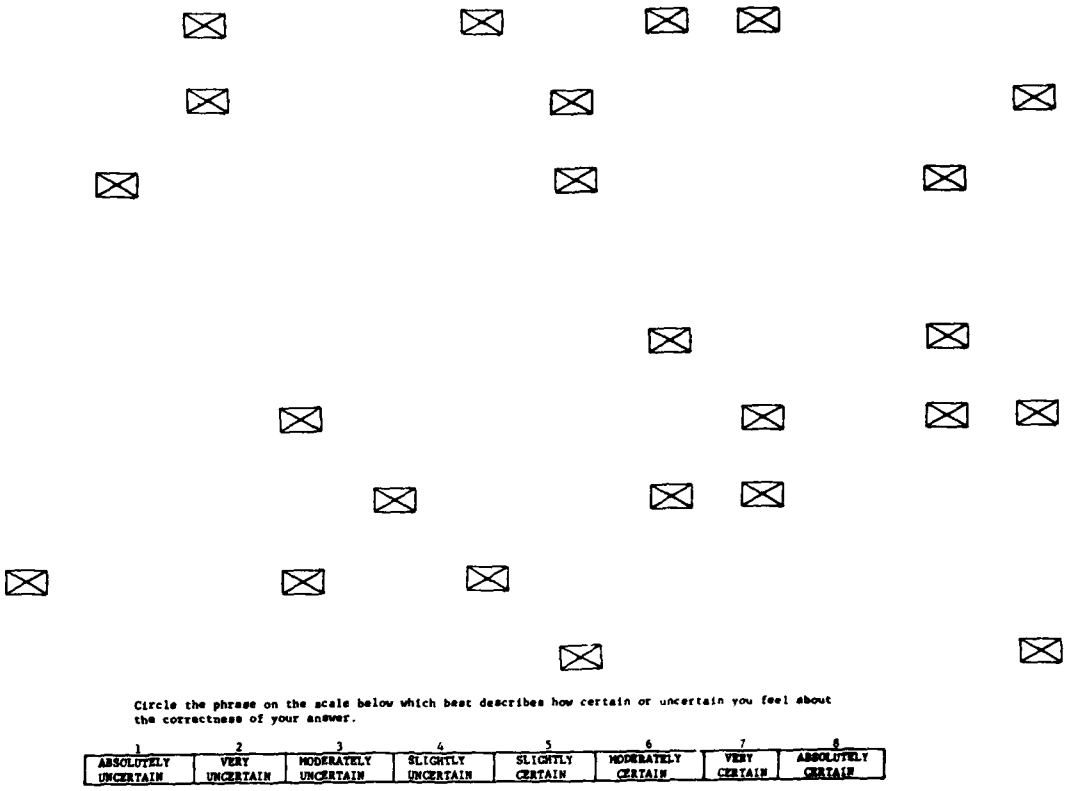


Figure 6. Reference slide for study of type and amount of change in information presented.

Hard Copy. Some information processing systems are planned in which much of the information is highly transient and almost everything except current information is "dumped" out of the system. The utility of hard copy, alone and in conjunction with "fleeting" information, deserves considerable attention. The contribution of hard copy toward providing a better sense of continuity and trend and for enhancing information feedback is self-evident. However, does hard copy in fact contribute toward a better base from which to make appropriate and timely decisions? Or is the cost and time involved in the production, storage, retrieval, and perusal of hard copy inordinate with respect to possible gains?

Sequence of Information Receipt. Automated information processing systems include different levels of information detail and map and overlay scales. Individuals will vary in the order in which they go through these different levels and scales in the solution of problems. Examples from research testify to the inadequacy of work methods arrived at through "natural inclination". A series of studies will be conducted wherein experimental sequences developed for problems of different complexity will be tested against sequences preferred by individuals and groups.

Individual and Group Displays. When a group of individuals, each with different major responsibilities, are jointly involved in the solution of complex problems, can they work more effectively with a large group display or individual smaller display consoles, or some combination of these? One large display may enhance communication among the individuals viewing it. However, a number of smaller individual displays adds flexibility, in that all specialists can view independently and simultaneously those information facets most relevant to their special interest. After such viewing and consideration of information, all responsible individuals can then gather to view the large display and take advantage of rapid and personal interaction and communication to resolve the issues before them. Studies in this area will seek to test the validity and utility of these various procedures. The relative effectiveness of group, individual, and combined group and individual displays will be evaluated in a number of problem solving situations.

Visual and Auditory Displays. Only the visual and auditory media are used for information transfer in automated information processing systems. Because of certain limitations of the auditory sense--fewer dimensions for coding, attention demands, sequential arrival of information, rate of information transmission limited to speaking rate--more and more emphasis appears to have been placed on visual displays. It seems reasonable to question whether visual channels are overloaded, and whether auditory channels are being sufficiently exploited. What might be the optimal allocation of information transmission load to visual and auditory media? Some of the very limitations of the auditory sense can possibly be exploited. If the information is simple, if there are frequent and prolonged periods of quiescence, if some classes of information are better assimilated and utilized when presented in a particular sequence, auditory media might be preferable. Examples of studies in this area are a comparison of the merits of the two media for various classes of information, and the effect of differing allocations of information transmission load to sensory media. In addition, the simultaneous presentation of visual and auditory stimuli for purposes of information conspicuity, emphasis, and the like, will be investigated.

Certitude, Probability, and Credibility. The interrelationships of the nature of information presented, subjective feeling of confidence, and actual performance have implications bearing on (1) enhancement of performance and confidence by providing probability and credibility information; and (2) the possible use of relatively easily obtained certitude scores as intermediate criterion measures. The following exemplifies the studies envisaged:

Military situations and information will be depicted with and without accompanying data on credibility or sources of information (enemy, prisoner, photograph) and/or probability or validity of the information (P = .7 that the enemy missile is being readied to fire). Further, the statements of credibility and probability will be varied. Problems and

questions of varied complexity will be presented to the examinees. Again, accuracy, appropriateness, speed, and certitude of information assimilation and decision making will be measured. The data will be analyzed to ascertain the relationships among information, certitude, and performance variables. Also, the impact of these additional data on other information display characteristics will be investigated. For example, it is not known whether credibility and probability data over and above normal military information constitute an additional burden and result in decrement in performance, or whether the additional data will assist the recipient in wading through larger amounts of information.

Certitude Measurement. Several experiments have been outlined concerning appropriate methodology for eliciting and quantifying judgments of certitude. In an initial study dealing with type and extent of information change, findings from research on interval scales for measuring subjective judgments in areas other than certitude were adapted to a certitude measurement continuum. Individuals participating in the study indicated the degree of certainty they felt about their accuracy in assimilating information, using a rating scale containing eight categories--balanced positive and negative with no neutral position and each category verbally anchored (Figure 6). The results are being analyzed in terms of characteristics of the continuum as determined by successive interval scaling techniques. Interval widths, scale values of the intervals, reproducibility, and response information transmitted, and the like, will be evaluated in terms of the model used and in relation to typical findings for such scales in other areas.

In another study (see discussion of historical tie-back below) an attempt is being made to ascertain whether the nature of the symbols displayed has an appreciable effect on the pertinence and precision of certitude measures used in span of apprehension studies reported in the literature. Here, the nature of the scale and tachistoscopic exposure times were selected to duplicate those commonly reported in the literature. A scale analysis of the type described above should provide information not presently available in the literature about the underlying certitude continuum; and perhaps, by comparison with the results of the analysis of the eight-category scale, such studies will provide some gross indication of the relative suitability of scale types.

Depending on the results of these studies and the insights they provide regarding the nature of certitude judgments and their measurement, either minor modifications and refinements will be made and empirically tested, or a major project will be undertaken to develop a precise, quantitative, and meaningful methodology of certitude measurement.

Historical Tie-Back. Most of the studies planned will allow for visual presentation of information for "sufficient" or necessary duration. Tachistoscopic (brief exposure time) studies will also be conducted to ascertain whether the variables and phenomena dealt with in the present research program behave in the same way as those that have

been investigated in a large number of tachistoscopic studies. If considerable correspondence is found between the results of command systems studies and those that have been done in the past, the current research program may be able to capitalize on what has already been done and reduce the number of planned studies and the time allotted to experimentation.

One study accomplished by USAPRO concerned span of apprehension and certitude. Nine different amounts of military symbols (4, 5, 6, 7, 8, 10, 14, 18, and 22) were presented for .5 and .2 seconds to each of eight groups of four examinees. Estimates of the number of symbols presented and certitude ratings on a five-point scale, anchored on both ends with adjectives, were collected. Data are being analyzed to ascertain the relationships among number of symbols presented, exposure time, estimates of symbols presented, and certitude ratings.

PLANNED RESEARCH ON INFORMATION PREPARATION

Inasmuch as the USAPRO effort for the next few years will be concentrated on the functions of decision making and information assimilation from displays, the present research study deals only briefly with the screening, transforming, and input functions of the TOC. A more comprehensive and articulated statement of planned research on the information preparation functions will be prepared prior to implementation of research on those functions.

The experimental variables to be dealt with in research on the information preparation functions will tend to duplicate those investigated in the studies just outlined. The primary purpose will be to ascertain whether the findings concerning human performance in decision making and information assimilation are compatible with the speed and accuracy of human operations required in information preparation. The probable impact of research findings in decision making and information assimilation on load, speed, and accuracy of information preparation can best be seen in the context of the studies dealing with information specificity-generality, alpha-numeric and symbolic presentation of information, certitude, credibility, and probability in decision making, and type, extent, and rate of information updating. Findings in those areas can be expected to have an impact on information processing functions with respect to number, type, and rate of separate inputs, and the transformation, screening, and sorting categories required. Not so apparent--but of critical importance--is the effect of these variables on speed and accuracy of performance of input, transforming, and screening functions.

If findings are consistent across human functional areas, the number of problems involving trade-off will be reduced. If, however, there are practical and frequent discrepancies, the implications are as follows: (1) need to develop special work methods and trade-offs across the five critical operations in current and imminent systems and (2) need for radical re-conceptualization of the design of systems, to include modified

allocation of functions to man and equipment and the development of new equipment and devices. A certain amount of re-conceptualization and redesign will occur through "natural" technological evolution. For example, more direct input or transfer of information to computers and storage devices through data links may eliminate some of the input, transforming, and screening functions now performed by men.

FACILITIES FOR LABORATORY SIMULATION

In order to carry out the program of research outlined, some simulation of command information processing systems will be necessary. Approximately 2000 square feet of laboratory space has been allocated to the task for this experimentation. The following laboratory equipment is being acquired:

Visual Equipment. Two random access slide projectors, individual and group rear view projection screens, a tachistoscope, memory drum apparatus, photo relays, and an illuminometer.

Auditory Equipment. Tape recorders, a speech and white noise generator, speakers, individual headsets, microphones, and a decibel meter.

Complementary Equipment. DC power supply, a repeat cycle timer, micro switch boxes, and voice keys and relays.

Recording Equipment. A sound motion picture camera, one way viewing glass, time and event recorders, and electronic counters.

In the future, alpha-numeric and symbol input devices, computer facilities, rapid slide generating equipment, communications equipment (radio, teletype) will be needed. An additional 1000 square feet of space will be required to house the added equipment.

NEW DEVELOPMENTS

Finally, some effort will be expended in keeping abreast of new developments and future command information processing systems. The purpose is to avoid the obvious shortcomings of being bound to a particular generation of systems, to maintain a responsiveness to new needs through a flexible research program oriented toward providing findings with broad application. This effort will be carried out by continuing participation in research and development programs in the Army and other agencies such as the AN/MSQ-19 (ARTOC) program and the Visual Displays Working Group of the National Research Council Vision Committee, and attendance at information systems conferences and symposia.

SELECTED PUBLICATIONS DEALING WITH INFORMATION PROCESSING AND DISPLAY SYSTEMS

Publications of the U. S. Army Personnel Research Office

Andrews, R. S., and Ringel, S. Certitude judgments and accuracy of information assimilation in visual displays (in press).

Andrews, R. S., Vicino, F. L., and Ringel, S. Accuracy and certitude in the discrimination of visual number (in press).

Goldstein, L. G., and Ringel, S. Survey of human factors problems in missile and communications systems. Research Memorandum 60-17. October 1960.

Ringel, S. Increasing personnel effectiveness in electronic systems--status report, 30 June 1962. Research Study 62-5. July 1962.

Ringel, S. Tracking performance in the Missile Master Fire Distribution system. Paper presented at the 7th Annual Human Factors Engineering Conference, University of Michigan, Ann Arbor, Michigan. 3-6 October 1961.

Ringel, S. Human Factors research in complex electronic systems. Research Study 61-3. July 1961.

Ringel, S., and Hammer, C. H. Information assimilation from alphanumeric displays--amount and density of information (in press).

Ringel, S., and Smith, P. F. Tracking performance in the Missile Master--target load, tracking time, and rated proficiency. Technical Research Note 121. May 1962.

Ringel, S., and Vicino, F. L. Information assimilation from symbolic displays--amount of information presented and removed (in press).

Vicino, F. L. Analysis of the TOC and its automated counterpart AN/MSQ-19. Research Memorandum 62-7. September 1962.

Additional References

Adelson, M., Muckler, F. A., and Williams, A. C. Verbal learning and message variables related to amount of information. In H. Quastler (Ed.), Information theory in psychology. Glencoe Free Press. 1955.

Alluisi, E. A., and Martin, H. B. Comparative information--handling performance with symbolic and conventional arabic numerals: Verbal and motor responses. WADC Technical Report 57-196. April 1957.

Anderson, N. S., and Fitts, P. M. Amount of information gained during brief exposures of numerals and colors. J. Exp. Psychol. 1958, 56, 362-369.

Attneave, F. Application of information theory to psychology. New York: Henry Holt, 1959.

Baker, C. A., and Grether, W. F. Visual presentation of information. USAF: WADC Technical Report No. 54-160. 1954.

Baker, C. A., Morris, D. F., and Steedman, W. C. Target recognition on complex displays. USAF: WADC Technical Report 59-418. 1959.

Berger, C. Stroke width, form and horizontal spacing of numerals as determinants of the threshold of recognition: I and II. J. appl. Psychol. 1944. 28, 208-231; 336-346.

Blackwell, H. R., and Bixel, G. A. The visibility of non-uniform target background complexes: I--preliminary experiment. Ohio State University, Institute for Research in Vision: Technical Report Number 890-1. April 1960.

Bryden, M. P. Tachistoscopic recognition of non-alphabetic material. Canad J. Psychol. 1960. 78-86.

Carmichael, L., and Bearborn, W. F. Reading and visual fatigue. New York: Houghton Mifflin. 1947.

Chapanis, A., Garner, W. R., and Morgan, C. T. Applied experimental psychology. New York: John Wiley and Sons, 1949.

Coffey, J. L. A comparison of vertical and horizontal arrangements of alpha-numeric material. Human Factors J. 1961. 3, 2, 93-98.

Coleman, E. B., and Kim, Insup. Comparison of several styles of typography in English. J. appl. Psychol. 1961. 45, 4, 262-267.

Conover, D. W., and Kraft, C. L. The use of color in coding displays. USAF: WADC Technical Report 55-471. October 1958.

Coombs, C. H., and Pruitt, D. G. A study of decision making under risk. Willow Run Labs., University of Michigan: AD No. 236074, 1960.

Edwards, W. Reward probability, amount, and information as determiner of sequential two-alternative decisions. J. exp. Psychol. 1956, 52, 177-188.

Enoch, J. W. Effect of the size of a complex display upon visual search. J. Optical Society of America. 1959. 49, 3, 280-286.

Fitts, P. M. Human engineering for an effective air-navigation and control system. Washington, D. C.: National Research Council Committee on Aviation Psychology, 1951.

Fitts, P. M., and Seeger, C. M. S-R compatibility: Spatial characteristics of stimulus and response codes. J. exp. Psychol. 1953, 46, 199-210.

Fitts, P. M., and Deininger, R. L. S-R compatibility: Correspondence among paired within stimulus and response codes. J. exp. Psychol. 1954, 48, 483-492.

Ford Motor Company, Aeronutronic Division. Revision to ARTOC specifications. Aeronutronic Intra-company Memorandum. 15 June 1960.

Ford Motor Company, Aeronutronic Division. GRAPHDEN symbol keys. ARTOC Technical Report 5450-24. 20 October 1960.

Ford Motor Company, Aeronutronic Division. ARTOC user procedure manual. ARTOC Technical Memorandum 5450-46. April 1961.

Ford Motor Company, Aeronutronic Division. AN/MSQ-19 training plan. Aeronutronic Publication U-1476, Vol. I. January 1962.

Ford Motor Company, Aeronutronic Division. Operations Central AN/MSQ-19 (U)--Interim Progress Report, 1 August 1960 through 31 January 1962, Vols II and III. Aeronutronic Publication U-1542. 10 February 1962.

Ford Motor Company, Aeronutronic Division. Mobile command and control system for battlefield headquarters--A highly flexible combat headquarters with mobility, interchangeability, tailoring, echeloning. Aeronutronic Publication U-1572 (Revised), 1 June 1962.

Ford Motor Company, Aeronutronic Division. TACDEN study. Intra-company Communication, 22 August 1962.

Ford Motor Company, Aeronutronic Division. GRAPHDEN study. Intra-company Communication, 4 September 1962.

Ford Motor Company, Aeronutronic Division. AN/MSQ-19 display service center. Aeronutronic Technical Report U-1634, 16 April 1963.

Ford Motor Company, Aeronutronic Division. Auxiliary console--AN/MSQ-19. Technical Note. Undated.

Garner, W. R., and Hake, H. W. Amount of information in absolute judgments. Psychol. Rev. 1951, 58, 6, 446-459.

Gerathewohl, S. J. Conspicuity of flashing and steady light signals: II. High contrast. USAF School of Aviation Medicine, Project No. 21-24-014, Report No. 2. Undated.

Graphics Division, U. S. Army Engineers Geodesy, Intelligence and Mapping Research and Developments Agency, Fort Belvoir, Virginia. Micromaps for display systems. Staff Study, 1962.

Green, B. F., and Anderson, L. K. Color coding in visual search task. J. exp. Psychol. 1956, 51, 19-24.

Harcum, E. R., and Blackwell, H. R. Visual recognition along various meridians of the visual field: XI. Identification of the number of blackened circles. Project Michigan, Report No. 2144-31-T. December 1958.

Headquarters, Department of the Army. Tactical operations center. TC 101-2, 25 May 1960.

Henneman, Richard H., and Mathews, Thomas L. The influence of message length and distracting task complexity. USAF: WADC Technical Report No. 54-145, April 1955.

Hitt, W. D., Schutz, H. G., Christner, C. A., Ray, H. W., and Coffey, J. L. Development of design criteria for intelligence display formats. Human Factors J., 1961, 3, 86-92.

Hodge, M. H., and Reid, L. S. The influence of irrelevant information upon complex visual discrimination. SGO Technical Report 537-58-2, July 1958.

Holland, James G., and Lee, William A. The influence of message distortion and message familiarity. Aero Medical Laboratory: WADC Technical Report 54-287, April 1955.

Intelligence Design Team, Systems Design Division, ADP Department, USAEPG, (Military Technical Developers); Intelligence Organization and Doctrine Branch, U. S. Army Intelligence Combat Developments Agency, (Military User Guidance Agency); R. W. Division, Thompson Ramo Wooldridge, Incorporated, (Technical Contractual Assistance). Evaluation report--First Intelligence Simulative Test (FIST). 1 November 1962.

Kaufman, E. L., Lord, M. W., Reese, T., and Volkman, J. The discrimination of visual number. Amer. J. Psychol. 1949, 62, 498-525.

Klemmer, E. T., and Frick, F. C. Assimilation of information from dot and matrix patterns. J. exp. Psychol. 1953, 45, 15-19.

Klemmer, E. T., and Muller, P. F., Jr. The rate of handling information--Key pressing responses to light patterns. HFORL Memorandum Report No. 34, March 1953.

Klemmer, E. T., and Loftus, J. P. Numerals, nonsense forms, and information. AFCRC-TR-57-2, February 1958.

Knowles, W. B., Garvey, W. D., and Newlin, E. P. The effect of speed and load on display-control relationships. J. exp. Psychol., 1953, 56, 65-75.

Krulee, G. K., Podell, J. E., and Ronco, P. C. Effect of number of alternatives and set on the visual discrimination of numerals. J. exp. Psychol. 1954, 48, 75-80.

Mackworth, Jane F. The effect of display time upon the recall of digits. Canad. J. Psychol. 1962, 16, 1, 48-54.

Miller, G. A., Bruner, J. S., and Postman, L. Familiarity of letter sequences and tachistoscopic identification. J. gen. Psychol. 1954, 50, 129-139.

Nahinsky, I. D. The influence of certain typographical arrangements upon span of visual comprehension. J. appl. Psychol. 1956, 40, 37-39.

Patterson, D. G., and Tinker, M. A. How to make type readable. New York: Harper, 1940.

Pollack, I. The assimilation of sequentially-encoded information. Amer. J. Psychol. 1953, 66, 421-435.

Pollack, I. Message uncertainty and message reception. J. acoust. Soc. Amer. 1959, 1500-1508.

Reynolds, G. W. Manual random access slide sorter. Ford Motor Company, Aeronutronic Division: Technical Addendum, January 8, 1963.

Rome Air Development Center. Criteria for group display chains for the 1962-1965 time period. Report No. RADC-TDR-62-315, July 1962.

Senders, J. W. Man's capacity to use information from complex displays. In H. Quastler (Ed.). Information Theory in Psychology. Glencoe Free Press, 1955.

Tufts College Institute for Applied Experimental Psychology. Handbook of Human Engineering Data, Second Edition (revised). November 1962.

U. S. Army Command and General Staff College. Evaluation Plan, Evaluation Test--Exercise MAGIC LANTERN, AN/MSQ-19. 11 April 1962.

U. S. Army Electronic Proving Ground. Fort Huachuca, Arizona. Fire support subsystem--White plan. October 1960.